



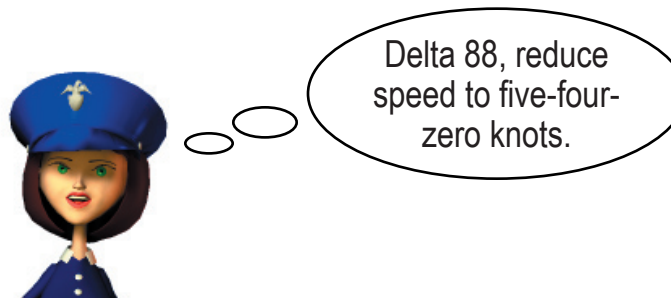
Math-Based Decisions in Air Traffic Control

Student Workbook E

- Resolving Air Traffic Conflicts by **Changing Speed**
 - **2 planes**, each at the same starting speed
 - Simulator Problems 2-4, 2-5, 2-6, 2-7, 2-8



- Simulator at: www.atcsim.nasa.gov



Investigator: _____

An Airspace Systems
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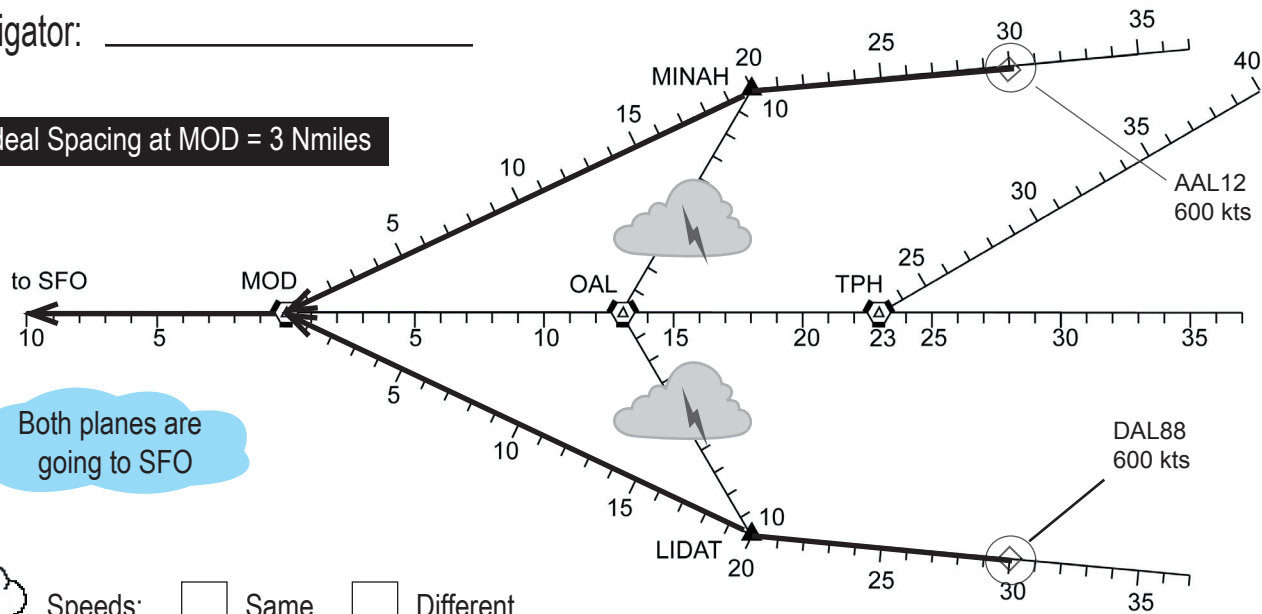


Problem 2-4



Investigator: _____

Ideal Spacing at MOD = 3 Nmiles



1

Speeds: ☐ Same ☐ Different

2

Headstart = Nmi = Separation at MOD

3

Additional Spacing
Needed for Ideal
Spacing (3 Nmiles)

Nmi

- ☐ To get the Ideal Spacing, you must change speed because the alternate routes are closed due to thunderstorms.

How Much Time Before You Need Ideal Spacing?

4

At 600 knots, how many minutes will it take the planes to reach MOD? mins

600 kts = 10 Nmi/Min

What Speed Change Will Solve the Problem?

- ☐ You can't speed up a plane because they are at the maximum speed of 600 kts.

5

Instead reduce the speed of one plane by 60 knots. Choose one plane to slow to 540 kts:

Remember: * A 60 knot difference in speed causes a 1 Nmile difference in distance each minute.



6

At 540 kts, how many nautical miles *less* will this plane travel *each minute*?

Nmiles per minute

7

In 3 minutes, how much *additional* spacing will you gain due to the speed reduction?

Nmiles

8

Does the 60-knot speed drop give Ideal Spacing at MOD?

☐ Yes

☐ No



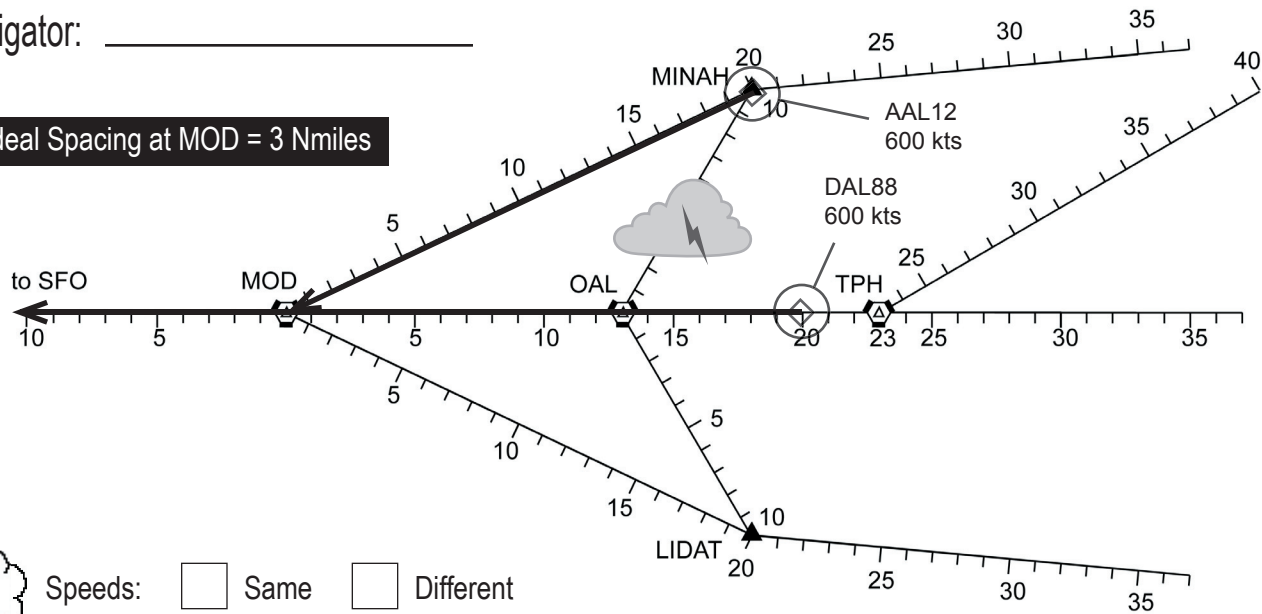


Problem 2-5



Investigator: _____

Ideal Spacing at MOD = 3 Nmiles



1

Speeds: ☐ Same ☐ Different

2

Spacing at MOD = Nmi

3

Additional Spacing Needed for 3 Nmiles = Nmi

☐ You must change speed to meet the Ideal Spacing.

4

At 600 knots, how many minutes will it take the planes to reach MOD? Minutes

600 kts = 10 Nmi/Min

Remember: * Controllers change speed in 60 knot steps.

* A 60 knot difference in speed causes a 1 Nmile difference in distance each minute.



☐ First, slow AAL12 (or DAL88) by 60 knots, to

5

At MOD, how much spacing will you gain? Nmiles

6

Did the 60-knot speed drop give you Ideal Spacing at or before MOD? ☐ Yes ☐ No

☐ Try a greater speed drop. Slow AAL12 by $60 + 60 = 120$ knots, to 480 knots.

7

Now how much spacing will you gain at MOD? Nmiles

8

Did the 120-knot speed drop give you Ideal Spacing at MOD? ☐ Yes ☐ No

9

If No, what else could you do to get exactly Ideal Spacing at MOD?

End of Worksheet



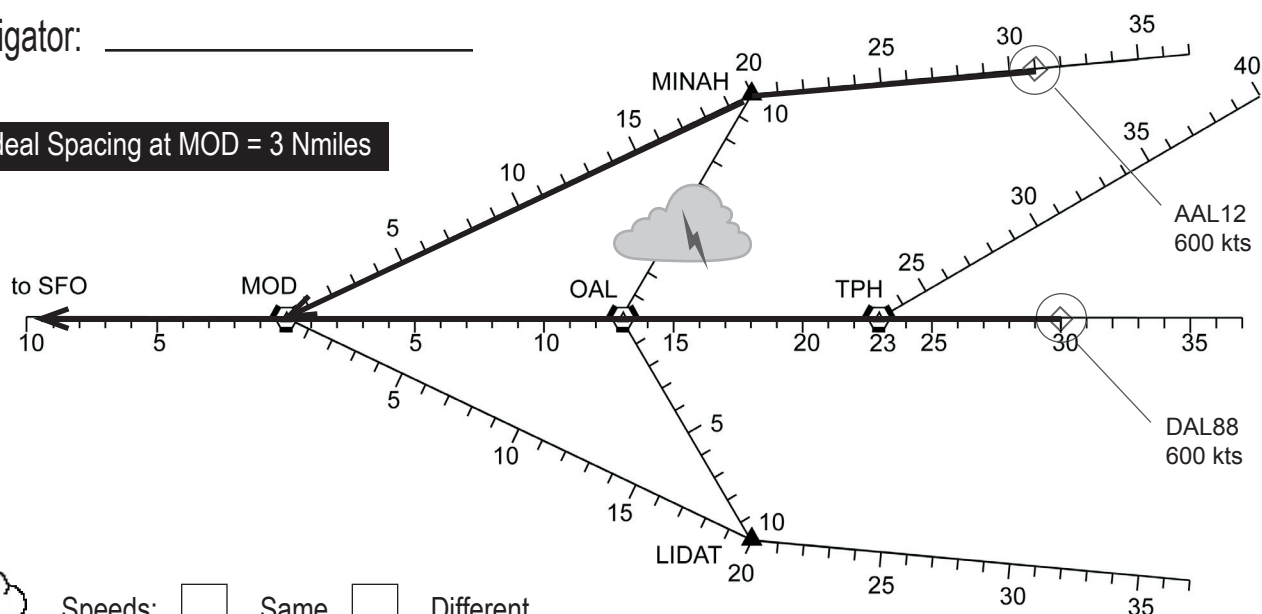


Problem 2-6



Investigator: _____

Ideal Spacing at MOD = 3 Nmiles



1

Speeds: ☐ Same ☐ Different

2

Spacing at MOD = Nmi

3

Additional Spacing Needed for 3 Nmiles =

4

At 600 knots, how many minutes will it take the **lead** plane to reach MOD?

Minutes

600 kts = 10 Nmi/Min

☐ Controllers usually slow down the trailing plane (*not* the leading plane).

5

Which plane would a controller slow down to 540 knots?

☐ A 60 knot difference in speed causes a 1 Nmile difference in distance each minute.



6

At this speed, how many nautical miles less will this plane travel *each minute*?

Nmiles *per minute*

7

At MOD, how much *additional* spacing will be gained due to the speed reduction?

Nmiles

8

What is the new spacing at MOD?

Nmiles

9

Is the spacing ideal?

☐

Yes

☐

No

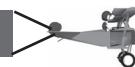
10

If no, after how many minutes will you speed the plane up to 600 kts to make the spacing ideal at MOD?

Minutes

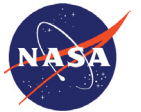


End of Worksheet



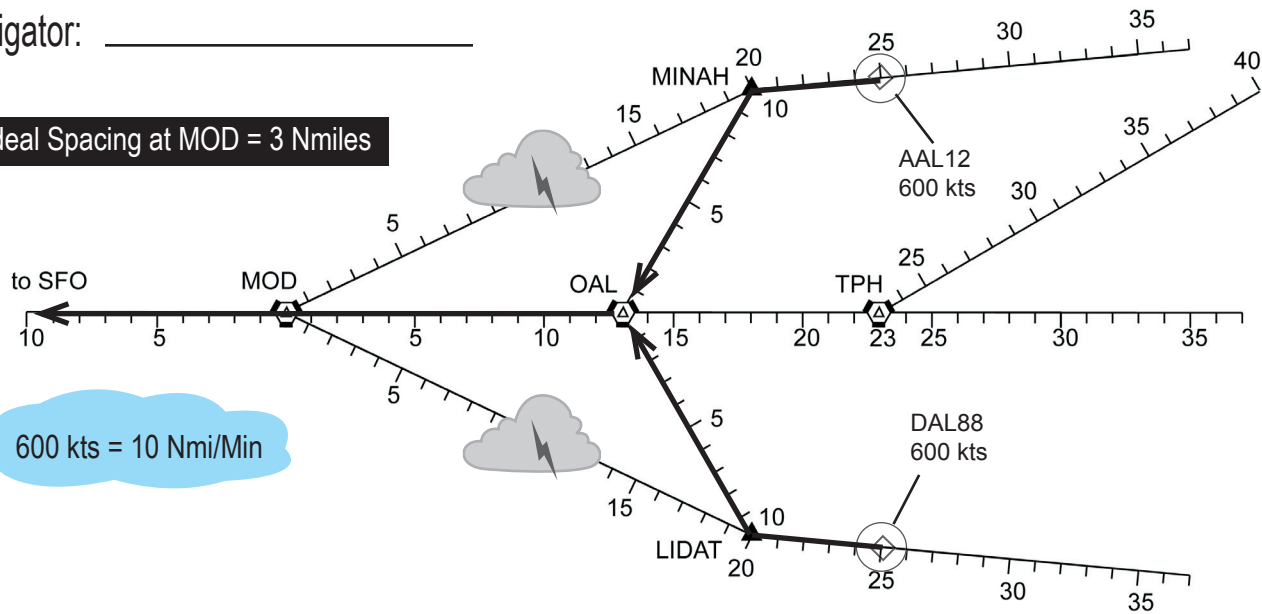


Problem 2-7



Investigator: _____

Ideal Spacing at MOD = 3 Nmiles



Remember:

- * Controllers change speed in 60 knot steps.
- * A 60 knot difference in speed will cause a 1 Nmile difference in distance each minute.

□ Analyze the problem at **OAL** (routes first meet). **MUST** meet or exceed **minimum** separation of 2 Nmi.

1

Spacing at **OAL** = Nmi



Additional Spacing
Needed for **minimum**
separation of 2 Nmiles

Nmi

□ Let's solve the problem by slowing one plane. Let's slow that plane to 540 kts.

2

Which plane will you slow?



3

At **OAL**, how much *additional* spacing will be added due to the speed *reduction*?

Nmiles

4

At 540kts, will the planes have at least **minimum** separation of 2 Nmi?

☐ No

☐ Yes



If No, what new speed will you use?

kts

5

At the new speed, what will the separation be at OAL?

Nmi

6

At your final speed change, do you get at least **Minimum** Separation at OAL?

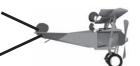
☐ No

☐ Yes

7

If Yes, when will you speed the plane up to 600 kts to get Ideal Spacing at **MOD**?

End of Worksheet



**EXTENSION**

- Now we will use a new method, the Percent Rule, to solve speed change problems.
Here's an example.



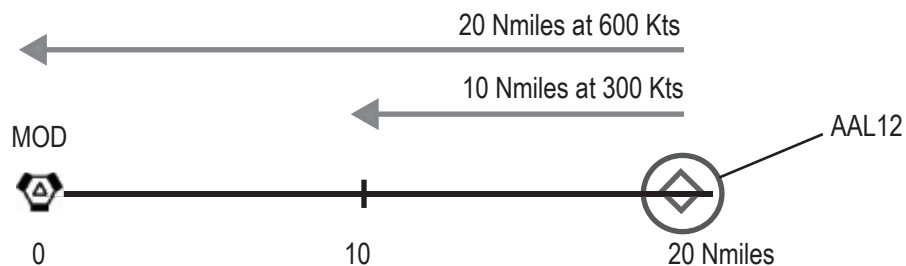
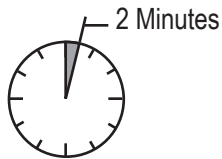
- At a speed of 600 knots, AAL12 travels 20 Nmi to MOD in 2 minutes.

600 kts = 10 Nmi/Min



If we decrease the speed by 50% (that's $\frac{1}{2}$ the speed), then the new speed is knots

- At 300 knots (a 50% decrease in speed), AAL12 travels only 10 Nmi (a 50% decrease) in 2 minutes.
Here's a picture,



- So, in two minutes, we have:

Percent	Speed	Distance Traveled
100%	600 knots	20 Nmi
50%	300 knots	10 Nmi

- The 50% decrease in speed gives a 50% decrease in distance traveled in the same time.
This is an example of the Percent Rule:

For a given amount of time, when you decrease a plane's speed by a given percent, the plane's distance traveled is decreased by the same percent.



Continue to Next Page

Investigator: _____



The % Method (continued)

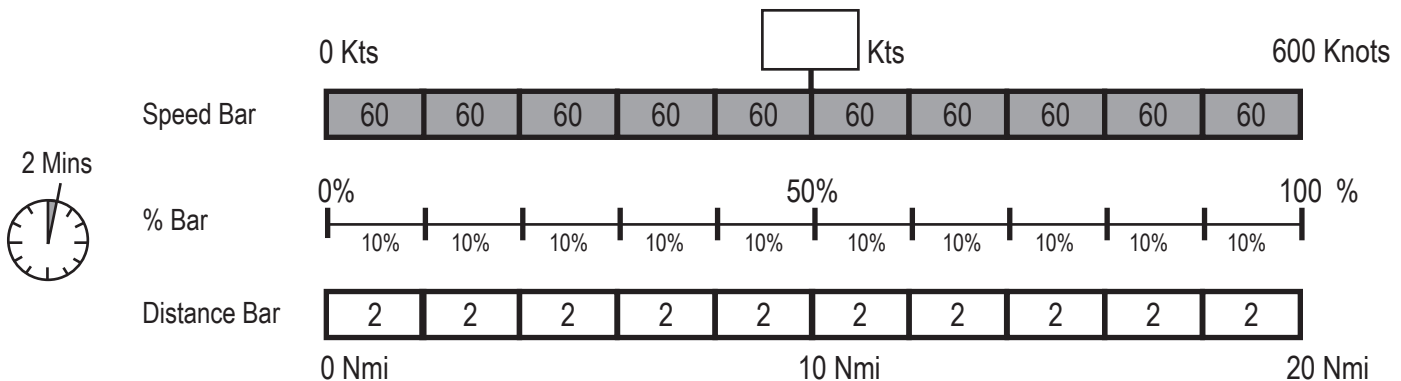


% decrease in speed = % decrease in distance traveled

Here's the Percent Rule.



- ✎ Now we will use the Percent Rule to get additional spacing at MOD.
- ✎ In the picture below, the plane's maximum speed, 600 kts, is shown in 10% intervals (60 kts each) on the Speed Bar.
- ✎ The plane is 20 Nmiles from MOD.
The distance to MOD is shown in 10% intervals (2 Nmiles each) on the Distance Bar.



Above the Speed Bar, in the empty box, fill in the plane speed that is 50% of 600 knots.

- ✎ Use this picture and the Percent Rule to answer Questions 3-5.



If we decrease speed by 60 knots, what is the % decrease in speed? %



Using the Percent Rule, what is the % decrease in distance traveled in two minutes? %



How many **fewer** nautical miles will the plane travel in two minutes?? Nmi

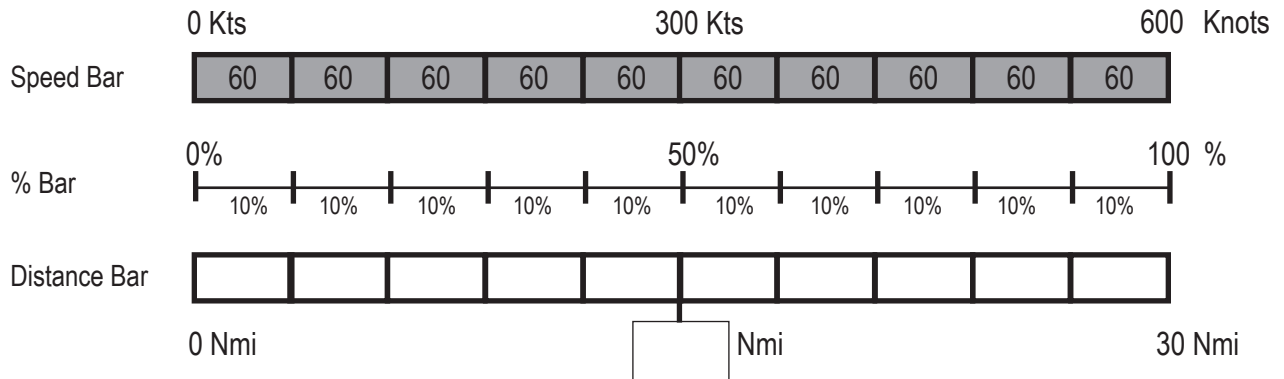
Investigator: _____



The % Method (continued)



- Now suppose the plane is **30 nautical miles** from MOD, traveling at 600 knots.



7

In the box below the Distance Bar, fill in the distance that is 50% of the **30 Nmiles** to MOD.

8

The distance to MOD is 30 Nmiles. For each 10% interval, fill each Distance Bar box with the number that is 10% of 30 Nmiles.

- Use this picture and the Percent Rule to answer Questions 9-12.

9

If we decrease speed by 120 knots, what is the percent decrease in speed? %

10

Using the Percent Rule, what is the percent decrease in distance traveled in the same travel time? %

11

Using this percent, how many **fewer** nautical miles will the plane travel? Nmi

- Now the plane speed is **again** 600 knots.
The plane travels **30 nautical miles** to MOD in a certain amount of time.
But we don't need to know this time to answer this question.

12

To travel 9 **fewer** nautical miles (in this same time) by what percent would you reduce the plane speed? %

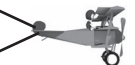
13

By how many knots would you reduce the plane speed? Knots

Wow! We didn't need to find "time" to solve these problems!



End of Worksheet



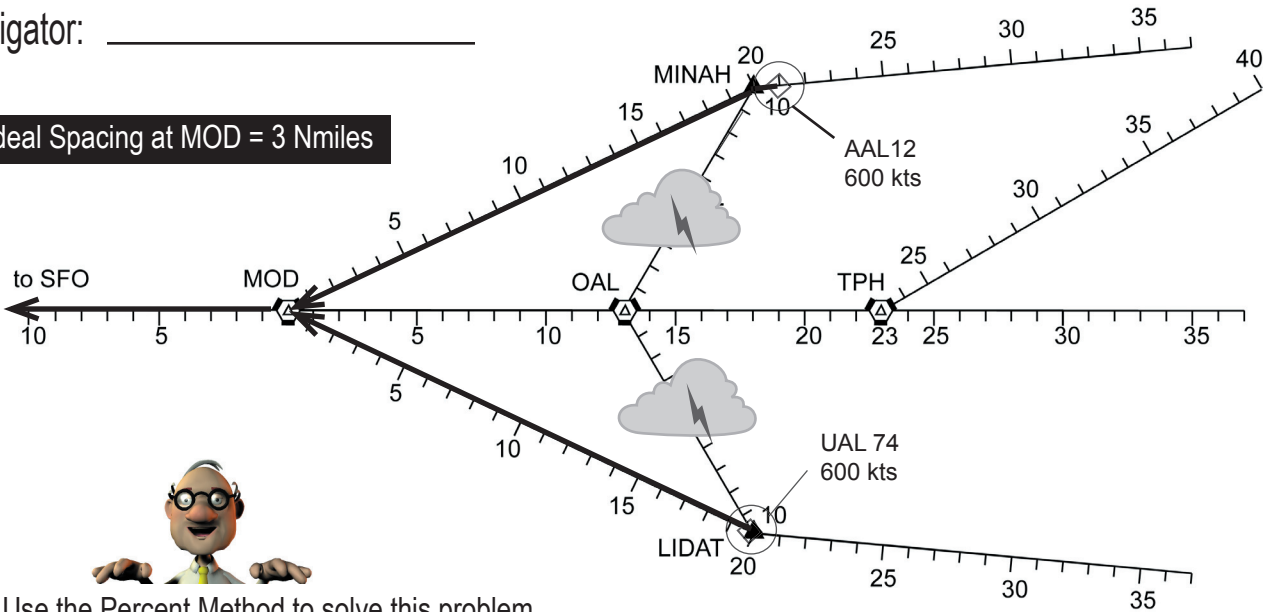


Problem 2-8



Investigator: _____

Ideal Spacing at MOD = 3 Nmiles



☒ Use the Percent Method to solve this problem.

1

Lead plane = Spacing at MOD = Nmi Additional Spacing Needed for 3 Nmiles = Nmi

☒ To achieve Ideal Spacing at MOD, decrease the speed of the trailing plane.

2

How many Nmiles does the *lead* plane travel to MOD? Nmiles

3

When the lead plane reaches MOD, the *trailing* plane has traveled ☐ the same ☐ a different distance.

☒ To get the additional spacing when the lead plane reaches MOD, decrease the trailing plane's 20-Nmi travel distance by Nmiles.

4

What is the percent decrease in travel distance for the trailing plane?

% Decrease = $\frac{\text{Additional Spacing Needed}}{\text{Distance Traveled}}$ = $\frac{2 \text{ Nmiles}}{20 \text{ Nmiles}}$ = $\frac{1}{10}$ = %

5

For the trailing plane: to decrease its travel distance by 10%, decrease its speed by %.

6

If you decrease the trailing plane's speed by 10%, what is its new speed? knots

7

What is the new spacing at MOD? Nmiles

End of Worksheet

